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The perform, achieve and trade scheme in India: An effectiveness analysis

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ABSTRACT

India's flagship scheme for energy efficiency is Perform, Achieve and Trade (PAT). Under PAT, obligated industries are required to achieve targets either by implementing energy efficient technologies or by purchasing energy efficiency certificates (ESCerts). We ask two questions: is PAT effective so far? Is PAT likely to be effective in future? We conclude the following: the targets are not strict enough to add energy efficiency activities beyond business-as-usual; long-term investment in energy efficiency may not happen; the PAT market may not form; many equity issues remain unaddressed; and, it is too early to assess transaction costs. Based on best practices, the policy implications are: set additional targets that account for rising energy costs; promote long-term investments via clear and consistent goals; create a functioning PAT market platform to ensure cost-effectiveness; reduce equity concerns via normalized targets and standardized auditing; and, keep transaction costs low.

1. Introduction

India has the third largest energy demand in the world [18]. Though the per capita energy consumption is lower than a third of the countries in the world there has been a simultaneous growth in the economy and population, resulting in a doubling of energy consumption since 1990 [31]. In this context, India faces three significant challenges in defining its energy policy: Energy Access, Energy Security and Climate Change. Energy efficiency is likely to play a major role in meeting these challenges.

Given that a significant portion of the total energy consumption – i.e., 45% in 2006-07 [8] happens in the industrial sector, energy efficiency measures within the industrial sector is an important aspect to achieve policy objectives. The Energy Conservation Act [19] identified energy intensive industries as designated consumers and provided them with a five-year time frame to: (1) establish the standards for energy consumption, (2) conduct mandatory energy audits through accredited auditors, (3) appoint plant-level designated energy managers, and (4) furnish information regarding the energy consumed and the actions taken to the designated agencies. Under the Act, the Bureau of Energy Efficiency (BEE) was established as the regulatory institution responsible for energy efficiency improvements.

In 2008, the National Action Plan on Climate Change (NAPCC) included the National Mission for Enhanced Energy Efficiency (NMEEE). Under the NMEEE, the Government of India has enacted a multi-pronged approach to achieve improvements in energy efficiency [26]:

1. Perform, Achieve and Trade (PAT) mechanism: A market based mechanism to enhance cost effectiveness of energy efficiency improvements within industrial plants. The goal of this scheme is to set energy efficiency targets and issue market tradable permits for certification of energy savings. This is similar to cap-and-trade schemes used in other contexts.
2. Market transformation for energy efficient appliances: a mechanism to shift consumers to energy efficient appliances through product labeling and awareness programs.
3. Financing platform for energy efficiency projects: a mechanism to help finance demand side management and energy efficient programs by capturing future energy savings.
4. Institutions: Strengthening of institutions such as the BEE and the state designated agencies (SDA) that are responsible for energy conservation, maintaining of energy databases and for accurate monitoring and verification of energy use through audits.

The overall goal of NMEEE is to achieve savings of 23 million metric tons of oil equivalent through an avoided capacity of 19,000 MW [39]. However, this raises the question: is NMEEE on target? And more importantly, will it be on target? In particular, what is the current and likely performance of BEE's flagship policy, PAT? How would its perfor-

Abbreviations: BEE, Bureau of Energy Efficiency; DCs, designated consumers; ESCerts, energy efficiency certificates; NAPCC, National Action Plan on Climate Change; NMEEE, National Mission for Enhanced Energy Efficiency; NPV, net present value; Performance, PAT, Achieve and Trade; SEC, specific energy consumption; SDA, state designated agencies; toe, ton of oil equivalent

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mance relate to design and implementation? Based on the COP21 summit, additional goals of reducing the emissions intensity of its GDP by 33–35% by 2030 from its 2005 levels [57]. PAT is expected to be a key component to this decrease in energy consumption.

Stern [53] outlines three main objectives of international cap and trade schemes: effectiveness, efficiency, and equity. Based on these objectives, we have established three significant research questions that help evaluate the design and performance of PAT:

- Has the PAT scheme been *effective*?
- Has the PAT scheme been *cost effective*?
- Has the PAT scheme been fair – i.e., *equitable*?

The first research question explores the impact of the PAT scheme in driving energy efficiency improvements as well as the barriers to effectiveness. The second question assesses whether the improvements are being achieved at the lowest cost. And the third research question explores equity impacts. Our findings are supported by primary as well as secondary research and backed with quantitative data where available. We have also compared PAT with other cap and trade schemes to leverage best practices within the Indian institutional context.

2. Overview of the PAT scheme

There are a number of barriers impacting energy efficiency within the industrial sector in developing countries. These barriers include access to sufficient capital, uncertainty over the length of the payback period, hidden costs associated with energy efficiency investments, lack of information and split incentive issues [56].

In an effort to address the barriers to energy efficiency within the industrial sector, the Bureau of Energy Efficiency has implemented PAT. The goal is to create a transparent, flexible, and robust scheme to achieve energy efficiency measures within specific industrial sectors cost-effectively. The guiding principles for developing PAT are Simplicity, Accountability, Transparency, Predictability, Consistency and Adaptability [39].[2]

The PAT scheme involves identification of the highest energy consumers within each of the selected sectors. These entities are termed designated consumers (DCs). BEE would issue Energy Saving Certificates (ESCerts) to DCs based on respective savings. Each ESCert is equivalent to one ton of oil equivalent (toe). DCs that do not meet the targets will be required to either buy ESCerts to meet targets or pay penalties. The ESCerts will be tradable and bankable in a market.

2.1. Selection of sectors

For the first cycle of PAT, 478 designated consumers from eight industrial sectors have been assigned targets. These sectors include cement, iron and steel, chlor-alkali, aluminum, thermal power plants, pulp and paper, fertilizer and textiles. The second cycle of PAT will include 143 additional targets and include three additional sectors – Refineries, Railways and DISCOMs. The annual energy thresholds and total sector-wise energy savings are included in Table 1. Industries that are below these annual thresholds are not included within the PAT scheme. The expected savings of the scheme across all the sectors during the first cycle – i.e., 2012–2015 – is 6.68 million toe.

2.2. Baseline and target setting

Each DC is a specific facility, with its own assigned target. The main metric for evaluation is the gate-to-gate specific energy consumption (SEC).[3]

The gate-to-gate SEC (Eq. (1)) is specified as the ratio of net energy into the plant boundary to the total quantity of output exported from the plant boundary (Fig. 1). The boundary of the plant is defined to capture the entire net energy input to the boundary.

$$SEC = \frac{Energy\ \ Into\ \ Plant}{Product\ \ \ Output} \tag{1}$$

Energy input to the plant boundary includes Electricity, Solid fuel, Liquid fuel and Gaseous fuels. To standardize across fuel inputs, the calorific value of the respective fuel is converted to tons of oil equivalent. The SEC does not include energy consumed due to residential complex, mining operations, transportation, construction etc. Energy used from renewable sources is also not included.

The assignment of targets is done in a hierarchical fashion. First, the total PAT cycle targets are divided among sectors in proportion to their corresponding energy consumptions. For example, if a particular sector is 10% of the total energy consumption of the eight sectors, the targeted reduction is 10% of the total targeted savings, resulting in a sectoral savings target of .668 million toe.[4] The sectoral targets are further broken down into sub-sectoral targets based on the utilized processes. For example, in aluminum sector, this includes smelter and refinery sub sectors; for textiles, this includes processing/spinning/composite or fiber. The targets for each sub-sector are calculated in a similar manner to the targeted sector savings. Finally, within each sector, targets are calculated based on baseline plant level SECs.

The plant baseline SECs are estimated based on self-declared data submitted by DCs and approved by designated energy auditors. Estimation of the baselines are done based on data collected between April 2007 and March 2010. These values are expected to be further normalized and adjusted based on site specific characteristics; however, details of this process are not readily available.

The target for each facility is defined as a percentage reduction from the corresponding baseline. Facilities are benchmarked against the best performing plant within the sector. The best performing plant would receive the lowest target and others will be assigned with proportional values. Thus,

$$Plant\ Target\,(\%) = \frac{Plant\ SEC}{Best\ SEC} * X\% \tag{2}$$

where X% is the targeted SEC reduction of the best performing plant within the sub sector, and can be calculated by adding up all the plant-level targets under a certain category and equating the sum to the targeted sub sector saving, which has been calculated based on the sectoral and sub-sectoral energy consumptions.

$$\sum\left(\frac{Plant\ SEC}{Best\ SEC} * X\% * Total\ Energy\ Consumption\ of\ Plant\right) = Targeted\ Sub\ Sectoral\ Savings \tag{3}$$

Therefore,

$$X\% = \frac{Targeted\ Sub\ Sectoral\ Savings}{\sum\left(\frac{Plant\ SEC}{Best\ SEC} * Total\ Energy\ consumption\ of\ Plant\right)} \tag{4}$$

Overall, the less energy efficient DCs within each sector would have to achieve higher reductions than the most efficient DCs since the SEC of the best performing plant will be the lowest. The baseline SEC will be revised in the subsequent cycles and the targets are expected to get progressively more stringent [38].

2.3. Monitoring and verification of savings

During the compliance period, the DCs are required to submit annual reports called PAT assessment documents. The monitoring and

[2] Most of what follows within this section is from Ministry of Power [39].

[3] The SEC target is used for all the industrial sectors except for the power sector. For the power sector the targets are based on the operating efficiency and the design efficiency of the plant.

[4] These numbers are presented for illustrative purposes only.

Table 1
Designated consumers within each industrial sector [39].

Sector	Minimum annual energy threshold (in toe)	No. of DCs within sector	Total energy savings (in million toe)
Aluminum	7500	10	.456
Cement	30,000	85	.816
Chlor alkali	12,000	22	.054
Fertilizer	30,000	29	.478
Iron and steel	30,000	67	1.486
Pulp and paper	30,000	31	.119
Textile	3000	90	.066
Thermal power plant	30,000	144	3.211
Total		**478**	**6.686**

verification of claimed energy savings is conducted by accredited designated independent energy auditors. Each DC is required to appoint an energy manager responsible for the submission of the PAT assessment document. Verification of the claimed savings would be done at the end of the compliance period. Check verification, an ex-post measurement of the energy savings may also be done on case by case basis by the accredited energy auditors.

2.4. Issuance of ESCerts

Certification of the savings is required for the issuance of permits. It will be complete at the end of the first compliance period based on recommendation by the designated energy auditors. ESCerts will be allocated upon verification of the energy savings. Partial (early) issuance of certificates may be done prior to the end of the compliance period.

2.5. Trading of ESCerts

PAT is a multi-cycle process and each period is three years long. The first compliance period is March 2012–March 2015. Banking is permitted but for one consequent cycle only. It is mandatory that trading of permits happen electronically on the designated power exchange platforms – IEX and PXIL [40]. The permits will be unique and a database of traded permits will be maintained and be publicly available. Communication and exchange of information between the DCs, the BEE, and the energy auditors will be done through an online interface PAT-NET.

The certificates are issued based on achievement of the targets established by BEE. The price of the certificates will be determined by the market. The buyer of certificates will be the entities that do not achieve the targets and have a shortfall of certificates. The sellers of certificates will be the entities that over achieve the targets and are issued excess certificates. At this point the trading of certificates is limited between DCs. There is no secondary market for trading of certificates.

2.6. Penalties

According to the Energy Conservation Act [19], failure to comply with the energy targets would result in a penalty that “shall not exceed ten lakh rupees in the case of continuing failure, with an additional penalty which shall not be less than the price of every metric ton of oil equivalent of energy ...” [19].

BEE has calculated the price of a metric ton of oil equivalent as USD 200 (INR 10,154)[5] based on the amount and cost of total energy consumed by all the DCs [11]. This per unit price of energy is subject to recalculation based on BEE discretion (Ministry of Power, 2001). A non-compliant DC will pay a lump sum penalty of USD 20,000 (INR 1 million) in addition to the product of the ESCert shortfall and USD 200. The implicit average penalty is the USD 20,000 fixed penalty divided by total ESCert shortfall in addition to the USD 200 variable cost. This implicit penalty would be expected to be higher than the trading price of certificates.

[5] Conversion rate: 1 USD=INR 50.

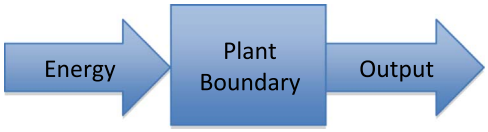

Fig. 1. Calculation of SEC.

2.7. Comparable Schemes

White certificate schemes have been implemented within the EU – i.e. France, Italy and UK. These are energy efficiency obligations combined with the issuance of tradable energy efficiency certificates based on achievement of established targets. Although cap and trade schemes for energy efficiency measures are not entirely new, the PAT scheme differs from such White Certificate schemes implemented in the EU, in that they are imposed on industrial consumers rather than directly on electricity and gas suppliers.

The PAT scheme is the first market based scheme targeted towards achieving energy efficiency within the industrial sector. Even though there are no comparable trading schemes, there are several other schemes that have been implemented globally for incentivizing industrial energy efficiency through mandatory energy efficiency targets, mandatory compliance with codes and standards, mandatory audits and public reporting of energy consumption.

For example, China's top 1000 energy consuming enterprises program identifies the top 1000 energy consuming enterprises (accounting for ~50% of the industrial energy usage) and required them to set up energy monitoring systems, carry out energy audits, achieve energy performance targets and prepare and submit reporting regarding their energy consumption [24]. Similarly, the EU Energy Efficiency directive requires all large enterprises in Europe to carry out an energy audit every four years. The goal of this directive is to achieve a 20% reduction in energy use across the entire community including governments, enterprises and power plants by 2010. Projections for 2020 show a primary energy consumption in of 1 842 Mtoe. A 20% reduction would amount to a reduction of 368 Mtoe [22]. Australia's Energy Efficiency Opportunity scheme encompassing 320 large enterprises requires these organizations to collect energy data, undergo energy assessments, identify energy efficiency opportunities and publicly report on their program outcomes. All enterprises that consume energy above a certain threshold are required to carry out an energy audit by the compliance date. Public reporting of the measures taken to reduce energy consumption is a key component of this program that is intended to put pressure on organizations to act.

Additionally, as discussed above in Section 1, the PAT scheme has been preceded by the Energy Conservation Act [19] which requires DC's to conduct mandatory audits, set energy efficiency baselines, appoint energy managers and mandatory reporting. As will be discussed in Section 4, market based schemes such as the PAT scheme are expected to be more cost effective than the above mentioned command and control schemes by achieving the energy efficiency targets at a lower cost. However, the success will depend on several factors including enforcement of the scheme, administrative costs, the functioning of the trading platform and the energy saving potential of the respective DC's. As we evaluate the PAT scheme in Section 4, we provide additional examples of other energy efficiency schemes and evaluate the design features of the PAT scheme in relation to these schemes.

2.8. PAT institutional structure

Table 2 provides a synopsis of the roles of each institution under the PAT scheme.

Table 2
Institutional responsibilities under the PAT scheme [39].

Institution	Role
Ministry of power	Oversee electricity production and act as intermediary between the Central Government and State Electricity Boards.
Bureau of energy efficiency	Regulate the PAT scheme
Energy efficiency services Ltd.	Approve Auditors and Set DC Targets
Designated consumers	Obliged Entities required to achieve PAT targets
Designated energy auditors	Monitor the PAT scheme; verify ESCerts
Power exchange India Indian electricity exchange	Establish and operate the Trading Platform for ESCerts
State designated agencies	Levy penalties; maintain and review verification reports; provide recommendations to BEE

Table 3
PAT stakeholder Interview.

Stakeholder-sector	No. interviewed	Entity
Aluminum	1	Hindalco
Chlor Alkali	3	Reliance, Chemplast, Grasim
Fertilizer	3	Tata Chemicals, Nagarjuna Fertilizers
Textiles	1	Vardhman Group
Cement	3	Ultratech Cement (2), DCM Shriram Consolidated
Iron and Steel	3	Hitech Power and Steel, Essar Steel and Visveraya Iron and Steel
Auditors	1	SiriExergy

2.9. Prior studies

Most studies on the PAT scheme have focused on ex-ante analysis.

- [15] and [36] assessed preliminary design features of the scheme. They recommended design improvements in different areas – e.g., boundary setting, target setting, and the market mechanism.
- Bhattacharya and Kapoor [8] conducted an ex-ante analysis that evaluated various features of the scheme and provided suggestions for a way forward for effective functioning of the ESCerts market, including broadening and deepening the PAT scheme and reducing price volatility in the market.
- Janardhanan and Shrivastava [33] suggested adjustments and modifications with the goal of aligning the scheme with international mechanisms.
- [46] discussed the ability of the scheme to attract international finance.
- [12] conducted a stakeholder analysis assess preparedness of the involved sectors.
- Center for Clean Air Policy [10] assessed PAT against other white certificate trading schemes and, based on stakeholder analysis, provided recommendations on implementation of the scheme.

Whereas most studies have concentrated on an analysis of the PAT scheme prior to implementation based on secondary research, this study evaluates the scheme post implementation, based on primary as well as secondary research. This evaluation includes primary research through interviews with stakeholders within the industry, auditors and the BEE. Based on this, it then provides recommendations on design improvements required in subsequent cycles to make PAT more effective. Additionally, this paper compares specific features of the PAT scheme against international cap and trade schemes including the EU ETS and White Certificate schemes in the EU. Our review adds to the state of knowledge through this primary research, interviews and the detailed comparison with other schemes.

3. Methods

The primary sources of data for this study were: 1) information and presentations published through government institutions such as EESL and BEE; 2) information obtained from interviews with government institutions; 3) information obtained from interviews with the designated consumers; and 4) articles and reports published in the form of grey literature. The primary secondary source of information was the PAT Booklet published by the Ministry of Power.

Primary Research through semi-structured interviews was done in accordance with the questionnaire in Appendix A. We reached out to about 100 DCs; 14 DCs were eventually interviewed (Table 3). The respondents included either senior executives involved in managing the plant or senior/chief engineers of the plant involved in equipment upgrades. In addition, we conducted two interviews with BEE, one interview with EESL, and one interview with an auditor. The interviews were conducted between the months of May-July 2013. Overall, we conducted a total of 18 interviews.

No interviews were conducted with the power or the pulp and paper sectors. As specified by BEE [4], the state owned power sector DCs may be the only ones not able to achieve their targets and, therefore, lack of power sector feedback within the study could lead to a bias in the results. Additionally, the results presented are based on those respondents who were willing to participate in the survey. Due to this, a self-selection bias exists within the study since those responding may have had a higher involvement in the scheme and a more proactive management and approach to energy efficiency.

4. Results and discussion

4.1. Effectiveness of the PAT scheme

In this sub-section, we answer the following research question: *Has the PAT scheme been effective in improving energy efficiency?*

The effectiveness of the scheme is measured in terms of the ability of the scheme to promote energy efficiency investments. We not only explore the impact of the PAT scheme in driving energy efficiency improvements during the first cycle but also assess the potential impacts to effectiveness within future cycles. We also explore design barriers that may be limiting energy efficiency investments and how results from similar schemes could be leveraged.

4.1.1. Energy efficiency measures are likely to be driven by high energy costs and not PAT

For a policy to be effective, it is essential that it incentivizes change above and beyond the business as usual scenario, a property referred to as “additionality”.

It appears that PAT is not additional. The primary reason behind energy efficiency measures by the DCs appears to be rising energy prices. Amongst the DCs interviewed, a majority (i.e., seven) stated that their energy efficiency measures have been primarily driven by rising electricity prices. Thus, these cannot be considered additional as they

would have occurred in the absence of the PAT scheme as well.[6]

Further, to the best of our knowledge, no methodology for establishing additionality has been created under the PAT scheme. In the future, to establish additionality, a clear methodology would be required. Creating this methodology is not going to be easy. Classification of a project as additional is difficult because the baseline is no longer observable once the policy has been implemented. Further, criteria to assess additionality are often subjective and project specific, which makes it difficult to establish a universal measure [29]. Challenges to assessment of additionalities may arise for a number of other reasons. First, due to asymmetric information, the DCs may provide inaccurate information to establish favorable baselines [9]. Second, setting accurate baselines and classification of additionalities may require high administrative and transaction costs that could exceed the benefits of the scheme [27].

Despite these difficulties, much can be learned from other cap and trade schemes. For example, under the Clean Development Mechanism (CDM) scheme, a project cannot obtain credit unless the project provides reduction in emissions that are additional [48]. It is also instructive to examine the white certificate schemes in the UK and Italy. Within these schemes, suppliers of electricity and natural gas must prove their actions are additional [6]. In Italy, each project is evaluated based on an additionality coefficient, with the baseline being measured in terms of average energy savings for the technology under use [13]. In UK, the measures for low income households are considered additional, however they are required to obtain letters from landlords justifying the additionality [6].

4.1.2. The PAT scheme will increase awareness around energy efficiency and market-based mechanisms within future cycles

The Energy Conservation Act [19] mandated that DCs report their annual energy consumption and conduct regular energy audits. However, prior to the PAT scheme there was not much initiative from the DCs in meeting these requirements [58].

PAT changes this, given plant level targets and monitoring. Our interviews suggest that most plant level designated energy managers are now knowledgeable in regards to their energy efficiency measures and targets. All DCs interviewed were well versed in the requirements of the PAT scheme. Feedback from DCs also indicated involvement of sector-specific associations in not only spreading information but also supporting the DCs in ensuring compliance [12,49].

Thus, even though PAT is not expected to have an additional impact on energy reduction within the first compliance cycle, it is expected to have a long-term impact on awareness around energy efficiency and functioning of cap and trade mechanisms, and building the required infrastructure for future success, along the lines of EU-ETS. Phase 1 of the EU ETS scheme was established as a pilot phase (European Commission). This phase was established to prepare the platform for the future cycles of EU-ETS. The baselines established in Phase 1 were estimations, but this period was used to gather information regarding energy saving potentials. Additionally, the first phase of EU ETS established the infrastructure for monitoring, reporting and verification. This preparation was considered essential for the second phase.

4.1.3. The PAT scheme may provide a platform for knowledge exchange that could lead to adoption of technologies in the future

The PAT scheme may not directly incentivize technology until a robust market has been established, however it will provide a platform that could help generate exchange of knowledge that could further lead to the adoption of technologies in the future. The BEE has been conducting workshops for energy managers from each sector through their Knowledge Exchange Platform (KEP). The goals of the KEP are to facilitate an exchange of information within and between the industrial sectors through exchange of information and peer to peer learning. Within these workshops, DC's from that specific sector are encouraged to share best practices to encourage the promotion of technologies and lessons learnt as well as incorporate broader policy discussions around industrial energy efficiency. This is also expected to serve as capacity building of energy managers, auditors and various stakeholder and generating awareness around the scheme and the technologies available within the specific sectors [32]. The KEP also encourages conducting and publishing sector specific case studies in regards to implementation of technologies within each of the sectors including the energy reductions and the monetary savings achieved. The question however still remains as to whether the PAT scheme itself will incentivize these technologies or whether there are other reasons for adoption of these technologies as discussed in Section 4.1.1, such as rising energy prices, desire to move to more automated technologies, decreased maintenance costs of equipment etc.

4.1.4. Lack of clarity and consistency of rules within the PAT scheme could hinder effectiveness in the long-term

Clear and simple rules are instrumental in lowering the associated transaction costs for any cap and trade scheme [20]. Thus, the success of the PAT scheme depends on the ability to maintain clear and consistent rules, especially in early phases so as to build confidence and ensure long term participation. Certainty regarding future policies would have a positive impact on investor confidence and promote long term investments in energy efficiency.

Based on our research, there has been a lack of stringent timelines and rules. The start date for the PAT scheme was initially scheduled to be April 2011 but, due to delays in the collection of baseline SEC data, this was postponed to July 2012 [35]. Based on interviews with BEE [4] and EESL [49], a clear standardization and normalization process for SEC values has not been developed and is scheduled to complete by end of 2013. Based on revised normalization, BEE has suggested that the targets could be revised during the first compliance cycle. This may discourage future investments due to lack of predictability.

4.1.5. Lack of long term goals and uncertainty in future caps may hinder long-term effectiveness

The success of a cap and trade relies heavily on setting a “trajectory of caps” that becomes more stringent with time [52]. Long term goals provide indications of the long term certainty in costs. Uncertain costs, on the other hand, lead to uncertain investments [34]. A cap and trade scheme that develops both interim and long term caps provides a long term price signal that may promote investment in the development and deployment of new technologies to increase energy efficiency [52] Lack of such commitment leaves the scheme vulnerable to large uncertainties.

There appears to be no clarity on the future caps in the case of the PAT scheme. Lack of future caps leaves uncertainty around measures that require longer payback periods. Based on discussions with DCs, current investments almost always have less than three year paybacks. Although there is limited data to substantiate whether the DC's are considering longer term measures evidence based on these discussions suggests that DCs may be targeting only short-term measures with quick return on investments.

In this regard, it is instructive to examine similar cap and trade schemes, such as the EU-ETS scheme, where targets have been declared up until 2020. There will be a linear 1.74% decrease in the caps every year to allow for a 21% decrease in overall emissions by 2020 from 2005 [21]. This has the potential of giving industries a better sense of future requirements and long term goals.

Further, white certificate schemes in France, UK and Italy have promoted investments by allowing the investment lifetime to be up to 8–40 years. The savings from the measures are discounted, accumulated

[6] The designated energy manager of Reliance Industries (Chlor Alkali sector) suggested that in assessing the feasibility of energy efficiency measures, the penalty avoided from implementation due to the PAT scheme, was considered within the payback calculations in approving certain measures. Although not a sole reason for undertaking the measure, this made the schemes more economically viable or more attractive to undertake in the near future.

across the entire lifetime, and credited to the scheme in the year of implementation [28]. The difference in lifetimes has resulted in shorter-term measures in Italy as compared to France and UK [28], however.

4.1.6. It is unclear whether the penalties have been set sufficiently high to incentivize investments

Long term stable price signals are essential in promoting stake holder participation and allowing for long term investment planning. Price volatility may arise in a cap and trade scheme due to lack of knowledge about marginal abatement costs resulting from a wide variation in energy prices and technology costs [2]. PAT is vulnerable to high price volatility due to a wide variation in the SECs and energy saving potentials across the 478 DCs over 8 sectors.

Pre-defined penalties can assist in setting a price ceiling and reducing price volatility. An additional requirement to enable investments and trading would involve setting penalties that are above the transaction costs of trading within the market. This penalty should be set significantly high so as to incentivize the obliged entities to participate in trading and installing energy conservation measures.

It is not clear whether the penalties have been set high enough to incentivize investments in PAT. As it currently stands, any non-compliant DC would be required to pay a lump sum penalty of USD 20,000 in addition to a per unit penalty of USD 200/toe, which is calculated by BEE as the average cost of energy across all DCs. Based on the data provided by BEE, theoretically, these penalties may have been set too low.

First, the average expected investment is about USD 12.8 million (INR 640 million) per DC, given the expected total investment of USD 60 billion (INR 306 billion) [7]. However, based on interviews, most investments by DCs have been limited to capital investment of USD 20,000 – 30,000 (INR 1–1.5 million), reflecting the lump-sum penalty and not the expected investment. Second, the per unit penalty of USD 200/toe is much lower than the number calculated by us based on data provided by BEE: USD 915 (INR 45,772)/toe (Table 4).

A penalty value should prevent both non-compliance and not impacting the price of certificates [6]. In the SO2 allowance trading program a penalty of 10 times the marginal abatement costs resulted in 100% compliance [51]. Within existing white certificate schemes, penalties are based on the magnitude of under compliance. In France, the penalty is set at 2 Eurocents/kWh and The Italian scheme allows more discretion, by allowing for a grace period in the event that 60% of the annual target is achieved and takes into factors, such as the ability to meet the targets, magnitude of non-compliance and the financial situation of the company [6].

4.1.7. Banking across compliance periods may promote long-term effectiveness

Banking and Borrowing are features that assist in promoting temporal flexibility [47]. Banking is the concept of saving excess allowances for future cycles. Borrowing is the possibility of using allowances that will be issued in the future years during the current compliance cycle. The temporal flexibility associated with banking, borrowing assist in: 1) increasing cost effectiveness and 2) promoting longer term price stability (European Commission). The ability to bank could assist in building investor confidence which leads to measures that have a longer lifetime and also reduces long term price volatility [2].

Most cap and trade programs incorporate banking, such as the California Acid Rain Program, EU-ETS, and regional US cap and trade programs. In the case of EU-ETS, the first phase resulted in significant over-allocation, which caused prices to collapse in the absence of banking. In response to this, the second and third phase of EU ETS introduced banking, for decreased price volatility (European Commission). On the other hand, borrowing of certificates is not a common feature of Cap and Trade schemes.

The first compliance cycle of the PAT scheme is expected to result in over allocation of certificates that will possibly result in significant banking. It could also introduce the possibility of buyback from the government at a floor price. However, as future targets have not been declared, this may not be a significant issue if the quantity of banked certificates is taken into account in future targets. Banking, therefore, would be expected to assist in re-instating investor confidence within the first phase. However, banking under the PAT schemes is allowed between two consecutive compliance periods only.

Table 4
Total Investment per sector (data provided by BEE).

Sector	Savings (toe)	INR/toe invested
Aluminum	456,000	17,579
Cement	816,000	46,062
Chlor alkali	54,000	4626
Fertilizer	478,000	21,800
Iron and steel	1,486,000	7320
Pulp and paper	119,000	66,166
Textiles	66,000	52,408
Thermal	3,211,000	70,866
Total	6,686,000	45,772

4.2. Cost-effectiveness

In this section, we ask the following question: *Has the scheme been cost effective in bringing about the lowest cost investments?* We also discuss design features that could serve as either barriers or incentives in achieving the lowest cost reductions.

4.2.1. There is a low likelihood of the existence of a PAT market within the first compliance cycle

Well-designed Cap and trade schemes are argued to be more beneficial than command and control regulation as they promote cost-effectiveness [52]. But for the cap and trade schemes to be cost-effective they must have heterogeneous abatement cost functions [43]. A limited market for trading does not preclude a scheme from being environmentally effective but rather it may indicate that these reductions were not reached in the most cost effective manner.

In the first compliance cycle of the PAT scheme, there is a low likelihood of trading of ESCerts between entities, indicating that the targets will be achieved but not at the lowest possible cost. All the interviewed DCs as well as BEE have implied that the targets within the first compliance cycle will be achieved in house.[7] This would eliminate the need for a market for certificates. In the absence of a market, the notion of cost-effectiveness is immaterial.

4.2.2. The first compliance cycle could be impactful in establishing a platform

The lack of a market for certificates does not necessarily mean that the scheme has been ineffective. The objectives of BEE under PAT can be separated into two categories: 1) establishing a platform for a market and 2) a functioning ESCert market. Although not specifically stated, it is possible that BEE would utilize the current phase to establish a platform to create a market within the future compliance cycles. The platform can be established keeping in mind the goal of achieving cost effectiveness in future. Establishing this platform would include building the technical and institutional capacity, a strong monitoring and verification process, building investor confidence through clear and consistent rules, and minimizing transaction costs.

Similar to the EU ETS scheme, Phase 1 of the PAT scheme can be treated as a pilot phase. The first phase of EU ETS resulted in significant over allocation of certificates. This was primarily due to the lack of emissions data and setting of low emission caps. Over allocation of allowances caused the price of certificates to fall to zero

[7] As discussed in earlier sections, this analysis does not include feedback from the power sector. Due to the inability to pass on costs, state owned power plants may not be able to achieve their targets.

[21]. Once having obtained better information regarding emission reduction potential during Phase 1, tighter caps were established under Phase 2. Despite limited trading, Phase 1 succeeded in setting up the infrastructure for trading, monitoring, reporting and verification [21].

4.2.3. The scope and flexibility of the scheme could be broadened to permit cost- effectiveness

A successful cap and trade scheme relies on heterogeneity of abatement costs across the obliged entities. The broader the range of sources, the lower it makes the cost of achieving the target [52]. A broader program creates a larger scope for pursuing the lowest cost measures [34]. A cap across different sectors allows policymakers to counteract the uncertainties that may lie in any one sector within the economy.

The BEE has future plans of deepening and broadening the scheme – i.e. increasing the number of DCs and sectors by lowering the minimum annual energy thresholds over time. There is expected to be a wide variance in SEC across the different sectors which, when combined with the fact that there would be no limitations on the types of eligible technologies, bodes well for future cost-effectiveness.

The Acid Rain program in the U.S. owed some of its success to this flexibility in the use of technology. This flexibility led to technological innovation by incentivizing use of blends of low sulfur coal in lieu of adding scrubbers, therefore achieving the goals at much lower costs than was expected [17].

4.2.4. Very early to ascertain if market gaming will be a concern

One of the arguments against cap and trade schemes is that potentially valuable assets could be generated in form of certificates [44], and creating these assets could lead to rent seeking behavior through hoarding. Particularly, if a firm is expected to be a seller in that market, they may withhold their allowances to raise the prices of the permit. On the other hand, if they are expected to be a buyer, they may limit purchase to keep the price low [30].

It is currently too early to assess whether market gaming will exist within the PAT scheme. Limited understanding of the energy saving potentials and the balance of market power within the scheme could create market hoarding. Further, a lack of transparency would make the scheme more susceptible to gaming. That said, the PAT scheme includes a broad set of sectors with designated consumers of varying energy usage and energy savings potential. As discussed above, the first cycle of PAT covers 478 DC's within eight sectors. The second cycle of PAT is to be expanded to include a total of 621 designated consumers which would include three additional sectors i.e. the Railways, DISCOMs and Refineries [5]. Due to the broad range of DC's from within difference sectors with different energy saving potential, the potential for market concentration may be reduced.

The vulnerability of the scheme towards gaming would also depend on the preparedness of the scheme in regards to monitoring and conducting audits to review the self-reported data submitted by the DC's. The current process of auditing and normalization of the targets is underway [4]; however information regarding the preparedness of the scheme is not readily available. Submission of self-reported data by DC is required on an annual basis with verification done after each compliance period. The Federation of Indian Chambers of Commerce (FICCI) and The Alliance for Energy Efficiency Economy are involved in conducting capacity building and strengthening of the state designated agencies for implementation of the PAT schemes [1,25]. A number of capacity building workshops and PAT awareness schemes are being conducted across the country to prepare for the issuance of the certificates. Additionally, PXIL and IEA have had prior experience in setting up a platform for the REC market. Despite this, it is difficult to tell whether the institutions are adequately prepared enough for the challenges posed by the PAT scheme.

4.2.5. There is limited information available regarding vulnerability to fraudulent activity

There is limited information available regarding trading during the first cycle of PAT and whether there has been any fraudulent activity. The PAT scheme may be vulnerable to fraudulent activity as was seen within the EU ETS. The EU ETS was vulnerable to tax fraud due to the lack of a harmonized codes across the EU. Once such example of the challenges with the trans national issues within the EU due to differing tax rules wherein the permits were bought in countries without incurring a VAT (consumption based value added tax) and sold in countries where the VAT tax was received for selling the certificate. Although there is no information available whether the permits being transacted will be taxable within PAT, harmonization of codes may not be a significant issue since the scheme does not deal with trans national issues. However, other concerns for the scheme as seen within the EU ETS related to registering fraudulent accounts and fraudulent transactions may be a concern. Despite the fact that there is not much information available regarding the platform and the first cycle of trading, the IEX and PXIL have been utilized for electricity trading and REC trading since 2008 [45] and are therefore are expected to be an established mediums for trading of ESCerts.

4.2.6. It is too early to assess transaction costs

Transaction costs extend beyond the direct costs of energy savings measures [3]. In a tradable permit scheme, these consist of costs related to search, negotiation, monitoring & enforcement, and certification & approval [16,50]. Transaction costs decrease the value of certificates, reducing the cost effectiveness of the scheme [50]. To keep a cap and trade scheme as cost-effective as possible, it should be designed in a manner that minimizes the overall transaction costs, especially when the certificate prices are expected to be low [37]. In Great Britain, for lighting and insulation segments for tradable white certificate scheme, these turned out to be 10–30% of total costs [41] and 5–36% for overall energy efficiency policy instruments [42].

A number of transaction costs can potentially occur under the PAT regulation: 1) searching for technologies, 2) assessing the feasibility of measures, 3) implementation of measures, 4) audits, and 5) monitoring and verification. Additional transaction costs could arise due to the PAT market: 1) obtaining certification, 2) bargaining and negotiation for certificates, 3) buying and selling certificates through the trading platform, 4) understanding the rules of scheme, and 5) overcoming corruption and bureaucracy.

The PAT scheme remains vulnerable to a number of these above transaction costs especially as the cost of implementation of the scheme is expected to be high. Projects with higher costs of implementation are often associated with higher transaction costs and can often compose a large share of the costs especially when the certificate prices are low [37].

4.3. Equity

In this section, we ask the following question: *Has the scheme been fair – i.e., equitable?*

The equity/fairness of a scheme measures how much the involved entities are better (or worse) off due to implemented measures. There are two key issues related to cap and trade schemes: 1) fairness to the industry due to distribution of the costs of compliance amongst the DCs and 2) unfair burden to low income consumers/households [23]. Concerns in regards to fairness to the industries may arise from unfair allocation of baselines, targets and certificates. Fairness concerns to low income consumers may arise when the costs of measures are passed on to low income consumer who may already be spending a higher fraction of their income on energy.

4.3.1. PAT Scheme is not expected to impact low-income consumers during the first cycle

Energy efficiency measures are unique in that they not only reduce energy usage but also result in savings through avoided energy costs [23]. Thus, in many cases, the projects are likely to have positive net present value (NPV). However, in case of negative NPV projects, DCs may pass on the costs of compliance to consumers, which may impact

low-incomes consumers in an unfair manner [23]. For PAT, however, due to the short payback periods, the first compliance cycle is not expected to have much of an impact on the DCs. However, in the longer term, cost pass-through could potentially become an issue especially in the case of regulated sectors, such as thermal power and fertilizer. The tariff setting within the power sector in India has been and continues to be highly politicized. Despite reforms in the electricity sector the power tariffs are set lower than the cost to utilities due to political intervention [55]. Additional compliance costs incurred by thermal power plants through the PAT scheme may continue to face these challenges.

4.3.2. Ignoring site and sector specific characteristics could lead to equity issues

The primary equity concern in PAT is in relation to the DCs in respect to the methodology used in calculating the SEC baseline and targets. Currently, no standard auditing document exists, leaving the scheme open to significant inequity concerns [4,49]. BEE is currently preparing a standardization and normalization process; however, many issues remain.[8]

A significant concern is related to the definition of plant boundary. So far, BEE has based this on geographical boundary, and has not accounted for site specific characteristics. Entities that decide to move higher consumption activities off site could game the system, raising potential equity issues by DCs that are not able to do so [15].

Another concern is related to the PAT threshold, with the DCs on the margin being negatively impacted. For example, the current energy consumption of a specific DC within the cement sector, the only wet process cement plant, is 42,000 toe; and they are an obligated entity given the PAT threshold of 30,000 toe. However, according to them this threshold is not fair, given that other obligated cement companies have energy consumptions close to 100,000 toe. They believe that this threshold puts them at a competitive disadvantage compared to others since they would be more limited in terms of resources and may have less accessible energy improvements to be made.

Further issues may exist in relation to capacity utilization of plants. High fuel costs and shortages could reduce the production capacity of the plant, increasing the SEC. The scheme has also failed to address the decrease in capacity utilization that may arise from an economic recession and fluctuating demand. For example, the current production capacity of a plant owned by a DC within the fertilizer sector is significantly lower due to the natural gas shortages. If the shortages continue during the last year of the first compliance cycle they may not be able to achieve their targets. Siri Exergy, a firm involved in baseline SEC audits, has further confirmed that capacity utilization is a significant concern among the DCs [54]. BEE, having understood this issue, is working on providing normalization factors based on reduced capacity utilization; however this change will take place a year and a half into implementation.

Further, financing mechanisms and the availability of credit for smaller capacity plants may be higher and impact equity. A number of larger industries also have in house financing and auditing with the potential of significantly decreasing their costs (in addition to their benefits from economies of scale) that could lead to equity issues.

A significant concern has also been discussed with the DCs in terms of standardization of the products across different sectors. BEE currently assigns standardization values for the products produced by each DC but each DC has a product that may vary in terms of quality. Higher quality products often have higher SEC values. For example, based on an interview with a DC within the textile sector, the site specific factors do not account for products of higher quality. Further, facilities that run on manual labor have a much higher likelihood of achieving the targets than plants that are automatic since automatic plants are more modernized yet more energy intensive.

An additional equity concern is related to the process technology used in manufacturing. Based on a study by DESL [14], this can be seen as a significant issue since the choice of process includes factors such as weather conditions, access to raw materials and cost of fuel at the specific location. This issue is in part addressed by creation of sub-sector targets for different processes within each sector but is still challenging to standardize across the DC's.

4.3.3. Early energy efficiency action on part of DCs could impact equity of the scheme

The targets have been based on both benchmarking and historical data of the designated consumers. Benchmarking is a process of making best practice comparisons across the sector and the historical SEC data is used to calculate the baseline energy consumption. However, there may be a disadvantage in that certain industries that took early action prior or during the baseline years (2008–2010). They may be penalized with higher targets. For those DCs that may maximize their energy efficiency measures during the first cycle and capture the “low hanging fruit” may be disadvantaged. Banking for one cycle may alleviate these concerns.

Evidence of inequity due to early action was received as feedback from two fertilizer companies – Tata chemicals and Nagarjuna fertilizers. According to Nagarjuna Fertilizers, meeting the target would be very difficult for certain sectors within future cycles as energy efficiency of those sectors are already improved and are higher than other sectors. Prevailing energy efficiency & feasibility of improving the efficiency further should have been considered prior to arriving at the future targets. This would need to be taken into consideration for the next PAT Cycle. According to Tata Chemicals, they have been given a 1% reduction goal and after this there will be absolutely no margin to increase energy efficiency due to a number of factors. This is due to a number of technical and economic factors such as low financial returns on the technologies, lack of technical options, operational reliability issues with conversion to new technologies.

5. Conclusions and policy implications

Under the auspices of the NMEEE, the Bureau of Energy Efficiency's flagship policy is the Performance, Achieve, and Trade (PAT) scheme, which focuses on incentivizing energy efficiency in the industrial sector, by specifying sector- and facility-wise targets over eight sectors and 478 facilities. In its first cycle (2012–2015), PAT has mandated an energy reduction of 6.86 million metric tons of oil equivalent. Further, in order to achieve these targets in a cost-effective manner, PAT includes a market based mechanism to allow trading of energy efficiency certificates (EScerts).

We have analyzed the design, implementation, and performance of the PAT scheme, with a focus on the following questions which are linked to the policy objectives: Has the PAT scheme been *effective* in improving energy efficiency? Has the PAT scheme been *cost-effective*? Has the PAT scheme been *equitable*? Our findings are built on an analysis based on primary as well as secondary research. The focus is not only on past performances but also on the likely future performances. Our primary findings are listed below in relation to our objectives:

Objective 1: Has the PAT scheme been *effective* in improving energy efficiency?

- **The targets are not strict enough to be additional.** As discussed in Section 4.1.1, the targets established within the first cycle have not been set above the business-as-usual scenarios. The high energy prices would have incentivized these measures even in the absence of PAT and therefore is the key driver of increased energy efficiency.
- **Long-term investment in energy efficiency may not happen.** As discussed in Section 4.1.4, long-term energy efficient investment may not happen due to lack of clarity and consistency of the scheme and the absence of long-term targets. Targets are defined only for three years (one PAT cycle) and will not extend beyond the first cycle, with no indication of the future of the targets or the future of the scheme itself. Hence, majority

[8] The opinions expressed by the sample interviewees regarding equity concerns may or may apply to a majority of the designated consumers.

of the investments will be limited to three year payback periods.

Objective 2: Has the scheme been *cost-effective*?

- **The PAT market may not form, reducing cost-effectiveness.** As assessed in Section 4.2.1, due to over allocation of ESCerts, trading of ESCerts is unlikely to occur, and there will be a limited chance for a market to form. In absence of this market, the PAT scheme may not be able to achieve its cost-effective potential.
- **Very early to assess transaction costs.** Since trading has not started, it is too early to assess the transaction costs of the PAT scheme. It is also quite early to tell whether the market will be vulnerable to market manipulation. This has been discussed in Section 4.2.5

Objective 3: Is the Scheme equitable?

- **Many equity issues remain unaddressed.** There are key gaps in the design that may make the PAT scheme less equitable. These concerns have been discussed in Section 4.3.2. There are concerns surrounding lack of accounting for specific plant level characteristics, including: limited capacity utilization during fuel shortages, which will negatively impact efficiency; standardization of products while taking into account quality differences; and availability of financing mechanisms to smaller consumers.

The policy implications of our findings are:

- **Set realistic, additional targets that account for rising energy costs.** For future cycles, the targets should take into account the impacts of rising energy prices on energy efficiency measures. The targets must be re-evaluated periodically to account for measures that are only implemented above and beyond the business-as-usual scenarios. This would be essential in preventing over allocation of the certificates, and to ensure that trading of ESCerts does occur.
- **Promote long-term investments via clear and consistent goals.** Based on lessons learned from other cap and trade schemes, the current rules must be strengthened to instill investor confidence through clear and consistent long term PAT goals, which would ensure stable long term price signals and incorporate provisions that account for longer lifetime measures. This would require good technological understanding of each industrial sector, and could be done through a group of sector specific experts who would assist in transfer of knowledge and the creation of sector-specific marginal cost abatement curves.
- **Reassess the established penalties to ensure that they are set sufficiently high to encourage investment:** Since the current phase is expected to result in an oversupply of certificates, the penalties should be sufficiently high to encourage trading of ESCerts. However, for future cycles, the BEE must reassess the penalties and ensure that they align with the targeted goals and intended investments in energy efficiency.
- **Create a functioning PAT market platform to ensure cost-effectiveness.** Given the over allocation of certificates, recognizing that a market may not form, the first cycle should re-focus on driving awareness around PAT and simply building the PAT market platform through involvement of the stakeholders. This functioning platform can then be used in future cycles to drive trading, and ensure that the PAT scheme achieves its cost-effectiveness potential.
- **Reduce equity concerns via normalized targets and standardized auditing.** Clear guidelines for auditing and for target setting should be published to limit variability in calculations and assessments made by the auditing agencies. These guidelines should clearly address site specific characteristics such as capacity utilization and difference in quality of the products.
- **Assess transaction costs and ensure that they keep low.** Methods to account for transaction costs incurred by the facilities should be gathered through PAT assessment documents to ensure that they remain low, in order to ensure that sellers participate in the PAT market and make PAT more cost-effective.

In order to ensure that PAT is a success in the long-term, we recommend the following future work: better estimates of baseline scenarios in order to set realistic targets; estimation of supply and demand curves of EScerts, in order to predict market behavior; and to set penalties, to ensure timely compliance, as well as floor and ceiling prices, to limit market price volatility; estimating market performance over time.

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Appendix A. Questionnaire for designated consumers

We asked the following questions to the designated consumers:

1. Please list the energy efficiency improvement measures and date of implementation.
2. For each energy efficiency measure listed, please provide the following information

– Would they have been implemented without PAT? Why?
– Expected reduction in SEC due to each of these listed measures
– Implementation date of each measure
– Total cost of each measure
– Payback period of each measure
– Annual cost savings for each measure
– Also list any expenses incurred due to the measure (such as cost of retiring equipment, training and labor, hiring third parties, cost of credit etc…)

3. Are there any concerns with the established baseline SEC? Is the process fair? Please describe.
4. Are there any concerns with the process of normalization or baseline audits of the SEC across facilities? Please describe.
5. Are there any concerns with the established target SEC for the first compliance period? Please describe. How could these concerns be addressed or removed?
6. Do you expect to be buyers or sellers of certificates at the end of the first compliance period? Why?
7. What is the expected cost of certificates? Why?
8. What are the risks and barriers associated with the scheme? Please list both technical and financial barriers. How can they be addressed?
9. Partial Issuance of Certificates will be available after the first year. Will you be availing of this opportunity?
10. Please list any future potential investments and the foreseen date of implementation and expected reduction in SEC.

References

[1] Alliance for an Energy Efficient Economy. Capacity and requirements of state designated agencies in India. Commissioned by shakti foundation; 2013. ⟨http://216.144.202.178/~apnademo/shakti-foundation/site/wp-content/uploads/2014/02/sda%20final%20report.pdf⟩.

[2] Aldy JE, Stavins RN. Climate negotiators create an opportunity for scholars. Science 2012;337(6098):1043–4.

[3] Antinori C, Sathaye J. Assessing transaction costs of project-based greenhouse gas emissions trading. Berkeley: Lawrence Berkley National Laboratory; 2007.

[4] BEE. . Energy economist at bureau of energy efficiency. (Shrimali G, Bhandari D, Interviewers). Personal Interview; 2013.

[5] BEE. Presentation on perform, achieve and trade (PAT) scheme, Presentation; 2016.

[6] Bertoldi P, Rezessey , Lees E, Baudry P, Jeandel A, Labanca N. Energy supplier obligations and white certificate schemes: comparative analysis of experiences in the European Union. Energy Policy 2010;38(3):1455–69.

[7] Bhargava, P. Perform, achieve and trade (PAT) mechanism under NMEEE. Presentation, Bureau of energy efficiency; 2010.

[8] Bhattacharya T, Kapoor R. Energy saving instruments- ESCerts in India. Renew Sustain Energy Rev 2011;16(2):1311–6.

[9] Bushnell JB. Adverse selection and emissions offsets. Energy Institute at Haas, Working paper, 222; 2011.

[10] Center for Clean Air Policy . PAT mechanism: Stakeholder consultation and policy analysis. Stakehold Rep 2011.

[11] Chakaravarti K. Perform, achieve and trade (PAT)- methodology- baseline normalization, energy performance indicators, Targets and M & V. New Delhi; n.d.

[12] Confederation of Indian Industries. Commisioned by shakti foundation; n.d. Retrieved 2014, from ⟨http://www.shaktifoundation.in/cms/uploadedImages/Product-industry.pdf⟩.

[13] de Lovinfosse I, Janeiro L, Blok K, Larkin J. Measurement, verification and additionality of electricity demand reductions: final report–recast; 2012.

[14] Development Environery Services Limited (DESL). M & V protocol for cement sector perform, achieve and trade scheme. Supported by shakti foundation; 2014. ⟨http://shaktifoundation.in/wp-content/uploads/2014/02/mv%20protocol%20-%20cement.pdf⟩.

[15] Dube S, Awasthi R, Dhariwal V. A discussion paper on India's perform, acheive and trade (PAT) scheme; 2011.

[16] Dudek , Weiner . Joint implementation, transaction costs, and climate change. OCDE 1996.

[17] Ellerman AD. Ex post evaluation of tradable permits: the US SO_2 cap-and-trade program. Cent Energy Environ Policy Res 2003.

[18] Enerdata. Global energy statistical yearbook; 2013. Retrieved march 15, 2014, from world energy statistics: ⟨http://yearbook.enerdata.net/⟩.

[19] Energy Conservation Act. No. 52 of 2001. Retrieved March 15, 2014, from ministry of power, government of India: ⟨http://powermin.nic.in⟩; 2001.

[20] EPA. Cap and trade: essentials; 2013. Retrieved 2013, from ⟨http://www.epa.gov/captrade/documents/ctessentials.pdf⟩.

[21] European Commission. Emission trading system (EU ETS). Retrieved, 2014, from: ⟨http://ec.europa.eu/clima/policies/ets/index_en.htm⟩.

[22] European Commission. Energy efficiency directive. Retrieved, 2017, from: ⟨https://ec.europa.eu/energy/en/topics/energy-efficiency/energy-efficiency-directive⟩.

[23] Farber DA. Pollution markets and social equity: analyzing the fairness of cap and trade. Ecol Law Quat 2012;39:1.

[24] Fawkes S, Oung K, Thorpe D. Best practices and case studies forindustrial energy efficiency improvement – an introduction for policy makers. Copenhagen: UNEP DTU Partnership; 2016.

[25] Federation of Indian Chambers of Commerce. Capacity building workshops for practicing energy auditors. Submitted to shakti foundation; 2014. ⟨http://shaktifoundation.in/wp-content/uploads/2014/02/Final-report-Shakti-Final.pdf⟩.

[26] Ghosh P. National action plan on climate change. Prime Minister's council on climate change; 2009.

[27] Gillenwater M. What is additionality? Part 1: a long standing problem. Discussion paper no. 001, GHG Management Institute; 2011.

[28] Giraudet LG, Bodineau L, Finon D. The costs and benefits of white certificates schemes. Energy Effic 2012;5(2):179–99.

[29] Greiner S, Michaelowa A. Defining investment additionality for CDM projects—practical approaches. Energy Policy 2003;31(10):1007–15.

[30] Hahn Robert W. Market power and transferable property rights. Q J Econ 1984;99:753–65.

[31] International Energy Agency. Understanding energy challenges in India. Institute of industrial productivity & BEE, 2015. Action plan, knowledge exchange platform (2015–2017), New Delhi; 2012.

[32] Institute of Industrial Productivity. Fact sheet: Australia energy efficiency opportunities scheme, Retrieved 2017: ⟨http://www.iipnetwork.org/IIP_Australia_Factsheet.pdf⟩ Janardhanan N, Shrivastava M, 2012. MRV challenges of integrating national initiatives into international mechanisms. Institute of global environmental strategies, Japan.

[33] Janardhanan N, Shrivastava M. MRV challenges of integrating national initiatives into international mechanisms. Japan: Institute of Global Environmental Strategies; 2012.

[34] Keohane N. Cap and trade, rehabilitated: using tradable permits to control US greenhouse gases. Rev Environ Econ Policy 2009;3(1):42–62.

[35] Khan MA, Tanwar N, Shankar S, Connect C. Primer to India's perform, achieve and trade scheme for enhanced energy efficiency. Greenhouse gas market report 2011; 2011, pp. 38–42.

[36] Kumar R, Agarwala A. Renewable energy certificate and perform, achieve, trade mechanisms to enhance the energy security for India. Energy Policy 2013:668–76.

[37] Michaelowa A, Jotzo F. Transaction costs, institutional rigidities and the size of the clean development mechanism. Energy Policy 2005;33(4):511–23.

[38] Ministry of Power. PAT Consultation Document. New Delhi; 2011.

[39] Ministry of Power . PAT- perform, acheive and trade. New Delhi: Booklet; 2012.

[40] Ministry of Power. The Energy Conservation Act (Amendment) 2010. New Delhi, India; 2010.

[41] Mundaca L. Transaction costs of tradable white certificate schemes: the energy efficiency commitment as case study. Energy Policy 2007;35(8):4340–54.

[42] Mundaca L. Transaction costs of energy efficiency policy instruments. Proceedings of the European council for an energy efficient economy 2007 summer study; 2007b.

[43] Newell R, Stavins R. Cost heterogeneity and potential savings from market-based policies. J Regul Econ 2003;23:43–59.

[44] Nordhaus W. To tax or not to tax: alternative approaches to slowing global warming. Oxford University Press; 2007.

[45] Power Exchange India Limited. Trading of EScerts (Energy savings certificates); 2016.

[46] Regan K, Mehta N, . International finance and the PAT scheme. Verco; N.D..

[47] Rubin . A model of intertemporal emission trading, banking, and borrowing. J Environ Econ Manag 1996;31(3):269–86.

[48] Rulebook CDM. Large scale: what is additionality. CDM Rulebook; 2009.

[49] EESL. Technical lead at EESL. (Bhandari D, Interviewer). Telephone interview; 2013.

[50] Stavins . Transaction costs and tradeable permits. J Environ Econ Manag 1995;29.2:133–48.

[51] Stavins . A U.S. Cap-and-trade system to address Global climate change. Regul Policy Program 2007.

[52] Stavins . Addressing climate change with a comprehensive US cap and trade system. Oxf Rev Econ Policy 2008;24(2):298–321.

[53] Stern . Key elements of a global deal on climate change. Lond Sch Econ Political Sci 2008.

[54] Subramanyam G. Director siri exergy & carbon advisory services. (Bhandari D, Interviewer). Personal interview; 2013.

[55] Tongia R. The political economy of Indian power sector reforms. Program on energy and sustainable development working paper, 4; 2003.

[56] United Nations, Industrial Development Organization. Barriers to industrial energy efficiency: a literature review; 2011. Retrieved from United Nations, Industrial Development Organization. ⟨http://www.unido.org/⟩.

[57] UNFCC. India's intended nationally determined contribution; 2017. Retrieved from: ⟨http://www4.unfccc.int/submissions/INDC/Published%20Documents/India/1/INDIA%20INDC%20TO%20UNFCCC.pdf⟩.

[58] World Resources Institute, Climate and Development Knowledge Network., 2013. Climate and development knowledge network; 2013. Retrieved Jan 2014, from ⟨http://cdkn.org/2013/01/23224/⟩.